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(19)(CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) R-Enzyme-Treated Breakfast Cereal and Preparation Process

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Canada

CCA 3254 (10-89) 41

Background of the Invention

1. Field of the Invention

The invention relates to the preparation of cooked, formed cereal products and to such cooked, formed cereal products. The invention further relates to the preparation of shredded breakfast cereals and to such shredded breakfast cereals. The invention also relates particularly to the preparation of cooked, formed wheat products and to such cooked, formed wheat products.

2. Background of the Art

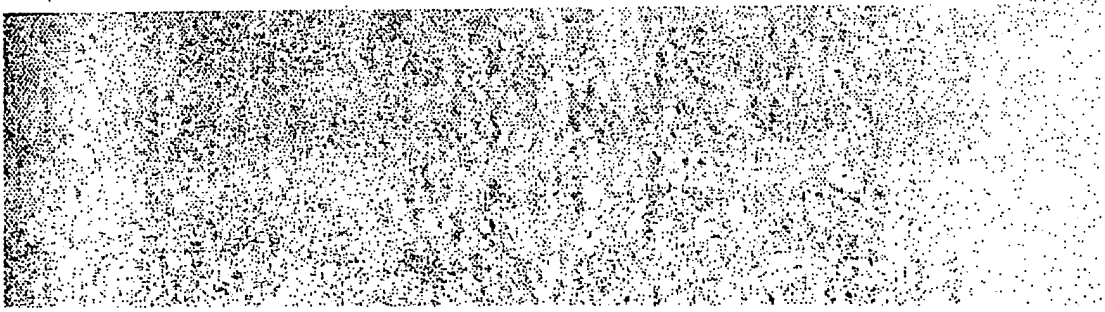
Starches are carbohydrate polymers of glucose and usually contain two components, namely, amylose, a linear, straight-chain, α-(1-4)glucopyranose polymer, and amylopectin, a randomly branched configuration of α-(1-4)glucopyranose units with periodic branching of sidechains with 1,6 linkages. Lineback, David R., et al., "Food Carbohydrates", Avi Publishing Company, Inc., Conn., (1982), page 287.

The structure of amylose is not well defined. It has a molecular weight of 150,000 to 1,000,000, depending on its biological origin. For a long time it was thought to be a linear glucose polymer in which the individual monomers were connected solely by α-(1-4)glycosidic linkages. It is now recognized that it has some elements of nonlinearity. Lineback, David R., et al., ibid., page 217. It has been concluded that amylose consists of a mixture of linear molecules and molecules with limited, long-chain branching

involving α-(1-6)linkages. The branches may be up to several thousand glucose residues in length and be multiply branched. Lineback, David R., et al., ibid., page 218. Amylose is generally a linear chained homopolymer. Amylose is humanly digestible.

Amylopectin is a ramified structure containing 94 to 96 percent of α-(1-4) linkages and 4 to 6 per cent of α(1-6) linkages. The average chain length is 20 to 26 glucose units. Lineback, David R., et al., ibid., page 218. Regarding determination of the structure of amylopectin, Lineback, David R., et al., ibid., states:

> "... in the 1950s. Since then the structure of amylopectin has been studied intensively with a combination of enzymatic methods, utilizing hydrolytic enzymes of defined specificity (e.g., β-amylase, pullulanase, isoamylase, phosphorylase, amyloglucosidase), and gel permeation chromatographic methods. In this approach, 'solubilized' starch is hydrolyzed enzymatically (Fig. 13.2). Hydrolysis is monitored by measuring the increase in reducing capacity. When the reducing capacity attains a constant value, the enzyme is heat inactivated, and an aliquot is fractionated on a calibrated chromatography column (i.e., Sephadex G-50). A subsequent digestion may be carried out with another enzyme. The size of the molecular subunits and their relative concentrations can be estimated from the elution profile. As a



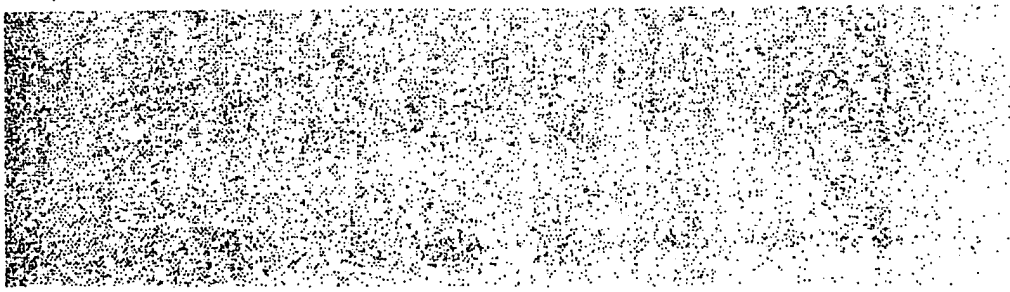
result of these types of experiments several new or revised models for amylopectin have been proposed." [Emphasis supplied] [page 220].

The molecular weight of amylopectin is in the order of 10^7 to 10^8. The amylopectin molecule is much greater in size than amylose but has linear chain lengths of only 25 to 30 glucose units. Lineback, David R., et al, ibid., page 242. Amylopectin has a low density of long outer branched chains.

In order to utilize starch, man must have enzymes that catalyze the hydrolysis of the (1,4) glycosidic bonds found between the α-D-glucopyranose residues. Enzymes which are capable of catalyzing the hydrolysis of the α-D(1,4) linkages are termed amylases. There are several different criteria by which amylases have been classified. One of the more common classifications is the α and β designation which is based upon the anomeric configuration of the products released. α-amylases release products with the α-D-configuration. and β-amylases release products with the β-D-configuration.

In general, β-amylases attack glucans in an exo fashion from the non-reducing end to produce a single type of low-molecular-weight product with the β-D-configuration. Limit dextrins result when the β-amylase reaches a branch point in amylopectin. The β-amylases cannot bypass an α-D-(1,6) branch linkage to attack α-D-(1,4) linkages on the other side of the branch point. Whistler, Roy L., et al., "Starch: Chemistry and Technology", 2nd Ed., (1984), page 88.

Glucoamylases, which are exo-acting amylases, release β-D-glucopyranose from the non-reducing end of the starch chain.



These enzymes differ from β-amylases in that they do not produce limit dextrins. Glucoamylases catalyze the hydrolysis of both the α-D-(1,4) linkages and the α-D-(1,6) linkages, although at different rates. Accordingly, glucoamylases can completely convert starch to D-glucose. Whistler, Roy L., et al., ibid., page 88.

De Man, John M., "Principles of Food Chemistry", The Avi Publishing Company, Inc., Conn., (1980), pages 358 and 359 discloses that the amylases, which are starch degrading enzymes, can be divided into two groups, namely, the so-called debranching enzymes that specifically hydrolyze the 1,6-linkages between chains, and the enzymes that split the 1,4-linkages between glucose units of the straight chains. The latter group is composed of endo-enzymes that cleave the bonds at random points along the chains and exo-enzymes that cleave at specific points near the chain ends.

Page 360 of De Man, John M., ibid., discloses that α-amylase is an endo-enzyme which hydrolyzes the α-1-4-glucosidic bonds in a random fashion along the chain. It hydrolyzes amylopectin to oligosaccharides containing 2 to 6 glucose units. Its action, therefore, leads to a rapid decrease in viscosity, but little monosaccharide formation. A mixture of amylose and amylopectin will be hydrolyzed into a mixture of dextrins, maltose, glucose and oligosaccharides.

Wheat is indicated to be a good source of β-amylase. De Man, John M., ibid., page 360. Non-damaged grains such as wheat and barley contain very little α-amylase but relatively high levels of β-amylase. Page 361 discloses that raw, non-

damaged and ungelatinized starch is not susceptible to β-amylase activity. In contrast, α-amylase can slowly attack intact starch granules. This differs with the type of starch. In general, extensive hydrolysis of starch requires gelatinization. Damaged starch granules are more easily attacked by amylases.

Debranching enzymes catalyze the hydrolysis of the α-(1-6) glucosidic bonds of starch (i.e., amylopectin), glycogen and their degradation products. α-amylases and β-amylases do not hydrolysis α-(1-6)glucosidic linkages of starch. There are direct debranching enzymes and indirect debranching enzymes. Direct debranching enzymes hydrolyze the α-(1-6) glucosidic bonds of amylopectin, etc., by splitting off side chains of varying lengths. The two main types of direct debranching enzymes, pullulanases and isoamylases, are based on differences in substrate specificity. Pullulanases possess the ability to hydrolyze poly α-(1-6)maltotriose. Allen, William G., et al., "Technology and Uses of Debranching Enzymes", Food Technology, (May 1975), pages 70 and 72.

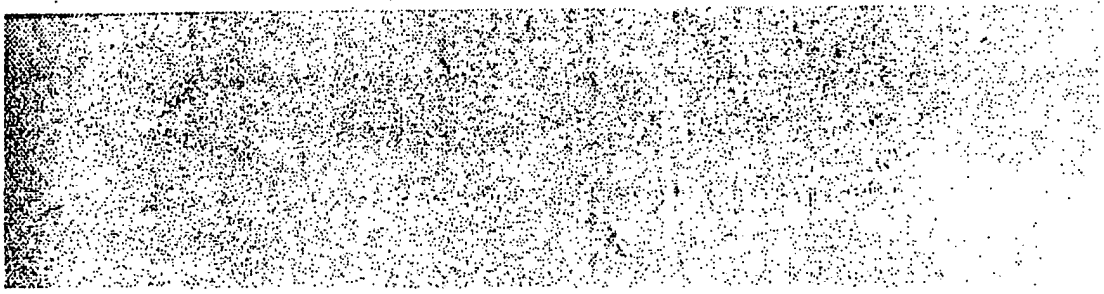
Allen, William G., et al., ibid., pages 78 and 80, asserted that debranching enzymes, due to their ability to produce limit dextrins from starch, would play an important role in starch technology. Isoamylases are stated to be suited to techniques in which straight-chain dextrins are first produced and subsequently treated with saccharifying enzymes.

Page 72 of Allen et al., ibid., discloses that R-enzymes are plant-derived debranching enzymes of the pullulanase type

and can hydrolyze the branch points of amylopectin and beta-limit dextrins. R-enzymes can be obtained from plants, such as, cereals, beans and potatoes. R-enzymes cannot attack glycogen beta-limit dextrins. Plant pullulanases cannot attack glycogen beta-limit dextrins. R-enzymes is subject to a greater degree of stearic hindrance than are microbial pullulanases.

Gunja-Smith, Zeenat, et al., "A Glycogen-Debranching Enzyme from Cytophaga", FEBS Letters, Vol. 12, Number 12, (Dec. 1970), pages 96 to 100, discloses that potato R-enzyme and bacterial pullulanase hydrolyse the α-(1,6)-linkages in pullulan and α-limit dextrins and cleave the α-1,6-branch linkages in amylopectin. Yeast isoamylase hydrolyses a limited proportion of the interchain linkages of amylopectin and glycogen but does not act on the 1,6-linkages of pullulan. Pseudomonas isoamylase and Cytophaga isoamylase hydrolyse the branch linkages of amylopectin and glycogen.

Abdullah, M., et al., "The Mechanism of Carbohydrase Action", "11. Pullulanase, an Enzyme Specific For The Hydrolysis of Alpha-1-6-Bonds In Amylaceous Oligo- and Polysaccharides", Cereal Chemistry, 43, (Jan. 1966), pages 111 to 118, discloses that pullulanase from Aerobater aerogenes is specific for the hydrolysis of alpha-1,6-glucosidic linkages in branched amylaceous polysaccharides and derived oligosaccharides. An example is amylopectin. The action and specificity of the pullulanase are closely similar to the plant R-enzyme complex, but pullulanase has the additional capacity to effect a limited degree of hydrolysis of the

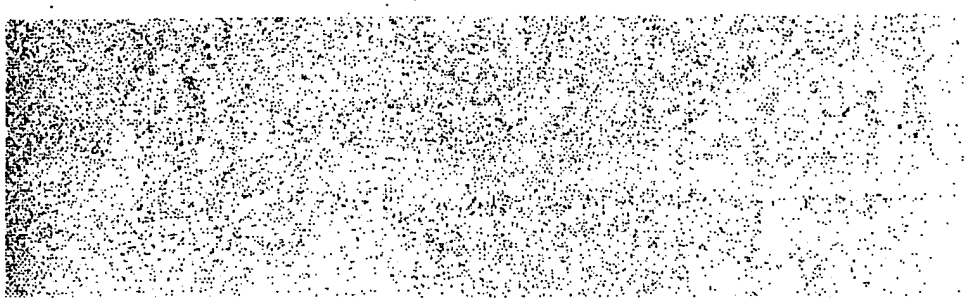


branch linkages of glycogen, which R-enzyme for steric reasons does not.

Drummond, G.S., et al., "On The Specificity of Starch Debranching Enzymes", FEBS Letters, Vol. 9, No. 3, (Aug. 1970), pages 136 to 140, discloses that R-enzymes hydrolyzes the 1,6-branch linkages of amylopectin. Pullulanase is termed a bacterial R-enzyme. When R-enzyme and pullulanase are diluted, the activity towards amylopectin selectivity disappears. R-enzyme is the same as limit dextrinase.

Manners, D.J., et al., "The Specificity of Cereal Limit Dextrinases", Biochem. J., 116, (1970), pages 539 to 541, discloses that limit dextrinase is an α-(1,6)-glucosidase that acts on branched oligosaccharide α-dextrins, but has no action or amylopectin. Manners, David J., et al., "Studies on Debranching Enzymes, Part VI: The Starch-Debranching Enzyme System of Germinated Barley", MBAA Tech quarterly, Vol. 14, No. 2, (1977), pages 120 to 125, discloses that limit dextrinase from germinated barley slowly hydrolyzes amylopectin. There is only one debranching enzyme obtained from germinated barley, not two, namely, R-enzyme acting preferentially on amylopectin and limit dextrinase acting only on branched α-dextrins. Manners, David J., "Debranching Enzymes In Plant Tissues", Biochem. Soc. Trans., Vol. 3, No. 1, (1975), pages 49 to 53, also asserts that R-enzyme is the same as limit dextrinase.

U.S. Patent No. 4,734,364 discloses a pullulanase derived from rice.



Hobson, P.N. et al., "The Enzymic Synthesis and Degradation of Starch. Part XIV. R-Enzyme", J. Chem. Soc. (London), (1950), pages 1451 to 1459, discloses that R-enzyme, obtained from potatoes and broad beans, catalyzes the scission of the branch links in amylopectin. R-enzyme does not convert amylopectin into amylose.

Lee, E.Y.C., et al., (Ed. Paul D. Boyer), "The Enzymes, Chapter 7, Glycogen and Starch Debranching Enzymes", Vol. 5, 3rd Ed., (1971), pages 191 to 234, discusses R-enzymes (plant pullulanases) on pages 202 to 204. R-enzyme and limit dextrinase appears to be the same entity. Bean R-enzyme cannot attack glycogen β-dextrin, whereas pullulanase from Aerobacter does. Aerobacter pullulanase is able to break most of the branch linkages of amylopectin, whereas bean R-enzyme breaks less than a majority. Sweet corn pullulanase (R-enzyme) has a slower rate of hydrolysis of amylopectin than Aerobacter aerogenes pullulanase.

Isoamylases, which are a type of debranching enzyme, hydrolyze the α-D-(1,6) linkages of amylopectin. Whistler, Roy L., et al., ibid., pages 88 and 89. Isoamylases do not hydrolyze poly α-(1-6)maltotriose. Allen, William G., et al., ibid., page 72. Isoamylase is unable to remove two and three-glucose-unit side chains of beta-limit dextrins and alpha-limit dextrins of oligosaccharides. The quantitative hydrolysis of amylopectin to maltose is not achieved with the simultaneous action of isoamylase and β-amylase. Allen, William G., et al., ibid., page 73.

Table 10.1 of DeMan, John M., ibid, page 350 indicates that amylases are used in the processing of cereals with the conversion of starch to dextrins and sugars, with the result of an increase in water absorption.

The gelling properties of the starches are dependent upon the amylose component which, because of its structure, can form hydrogen bonds with neighboring molecules and build up a three-dimensional network. Amylopectin, being highly branched, prevents close physical association between molecules, and thus, inhibits or prevents gelation. Typically, gel formation of starches takes place upon heating starch dispersions above the gelatinization temperature of the starch and then cooling the gelatinized solution. To speed up this process, starches can be pregelatinized by cooking and then drying starch slurries. Lineback, David R., et al., ibid., page 228.

The rate of retrogradation is greatest between pH 5 and 7. Lineback, David R., et al., ibid., page 432.

The manufacture of shredded wheat biscuits is disclosed in Matz, Samuel A., "Cereal Technology", The Avi Publishing Company, Inc., Conn., (1970), pages 231 to 235. Shredded wheat biscuits differ from most other prepared breakfast cereals in that it is made from whole grain without the addition of any flavor and without the removal of the germ or bran.

U.S. Patent No. 2,174,982 teaches a process for making shredded or flaked cereal foods from cereal grains such as wheat, rye, corn or oats. Here, the whole grain is boiled in

alkali to partially dissolve the bran coating. The grain is then washed to remove the alkali and then treated with malt to convert starch to dextrins. A flavoring substance is added to the wort, whereupon the wort is kept at 148° to 170°F to expand the grain and allow penetration of the flavoring substance. The material is then cooked under pressure, dried and either flaked or shredded. The moisture content of the material for shredding is 20 percent. Page 1, col. 2, lines 36 to 51, of Patent '416 states:

> "When whole grain cereal such as wheat is 'bumped' between steel rolls or otherwise partially flattened to about one-third its normal diameter, the outer bran coat is ruptured and the permeability of the endo-sperm is greatly increased without destroying the unity of the kernel. The starch of the wheat may be gelatinized by cooking with water before bumping, or such gelatinization can be readily obtained by subjecting the bumped grains to heat in the presence of moisture for a suitable period. We have discovered that when so treated the wheat can be acted on by starch splitting enzymes to convert the greater part of the starch in the individual kernels to dextrins and maltose without materially altering the contour of the bumped grains."

U.S. Patent No. 2,289,416 discloses a process for preparing a cereal from whole grain comprising rupturing the bran coat of the kernels, optionally gelatinizing the starch

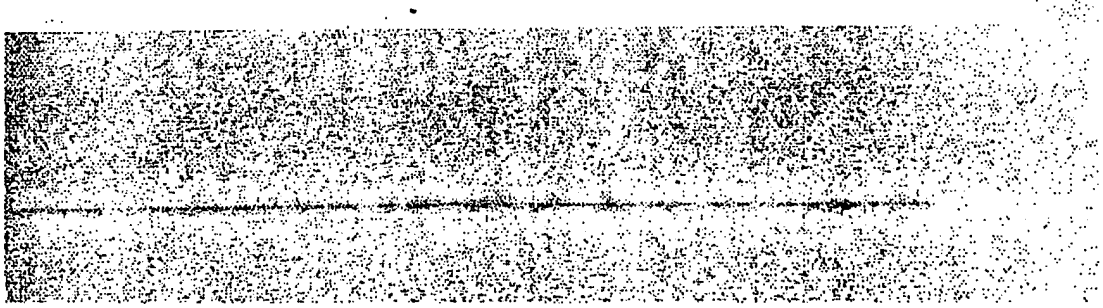
with heat (before or after the bumping), and then treating the gelatinized starch with a starch splitting enzyme to convert the majority of the starch to dextrins and sugars. The enzyme source is taught to be malted grain. After the treatment has been completed (in approximately 2 hours at 60° to 70°), the converted grain was heated to inactive the enzyme, dried, tempered and processed to produce a toasted product in flaked, shredded or other desired form. Page 1, col. 1, lines 7 to 39, the prior art portion of Patent '416 states:

> "Cereal products of this character as heretofore prepared have been of two general types; granular products prepared from cereal flour, and flaked or shredded products prepared from whole grain cereal, meaning that the term to refer to the physical unity of the cereal berry rather than to its composition. *** In the case of flaked and shredded products, on the other hand, the practice has been to add malt in the form of a liquor or syrup to the surface of the whole cereal grains, which have been slightly crushed or 'bumped' so as to break the bran coat but not destroy their unitary nature, and then to cook the same. Under these conditions no substantial conversion of the starch of the cereal grains is effected by the enzymes in the malt liquor or by the naturally occurring enzymes in the whole grain. As a result the proportion of dextrin and sugar and the level of malt flavor are dependent on the amount of malt

liquor which can be taken up by the grains and still give a product that can be conveniently processed. Since this amount is limited, such flaked and shredded products have possessed a lower proportion of dextrins and possessed a lower proportion of dextrins and sugars and level of malt flavor than the granular products and than has been considered desirable."

U .S. Patent No. 2,853,388 discloses providing a quick-cooking wheat product from mixing wheat and proteolytic enzymes. The whole wheat cereal grains are first reduced to granular form (e.g., ground, granulated or comminuted).

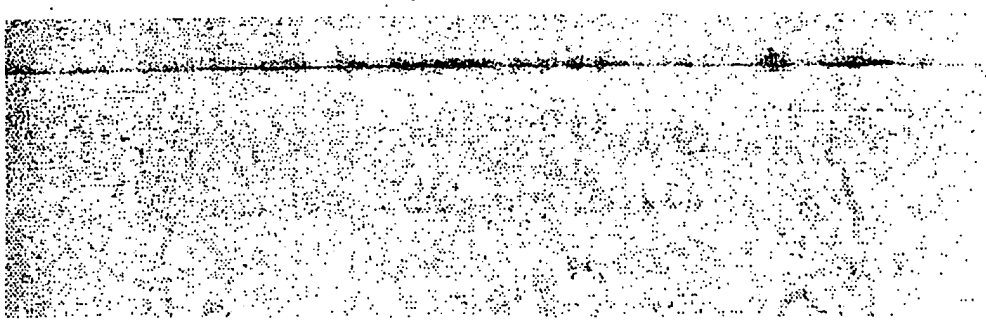
U.S. Patent No. 3,632,475 discloses a process for preparing long-chain amylose and short-chain amylose and separating one form the other. Starch is liquified at a temperature between 100° and 130°C. The resultant liquefied starch is cooled to 45° to 70°C. The process continues by adding to the liquefied starch α-1,6-glucosidase produced from bacteria in an amount sufficient to decompose substantially all the amylopectin contained in the starch into amylose. The long-chain amylose is precipitated by cooling the resultant mixture to about 45° to 40°C. The precipitate of the long-chain amylose is separated. Then the short-chain amylose is precipitated by cooling the residual solution below 5°C. The precipitate of the short-chain amylose is separated. When the Pseudomonas enzyme was used, the pH was 4.5 and the reaction was carried out at 45°C for 30 hours.



U.S. Patent No. 3,677,896 discloses preparing a high-purity maltose solution by the use of β-amylase for the amylolysis and also α-1,6-glucosidase which can eliminate from starch the α-1,6-glucoside bond that hampers the amylolysis by the action of β-amylase. An example of the α-1,6-glucosidase can be enzymes from the genera Pseudomonas (ATCC 21262). The resultant solution is concentrated to a massecuite containing maltose crystals. Then the massecuite is sprayed in a drying column to obtain the final product.

U.S. Patent No. 3,729,380 discloses a process for producing a relatively low molecular weight amylose having straight chain structure on a commercial basis by selectively hydrolyzing with α-1,6-glucosidase only the bonds of the branched parts in amylopectin molecules contained in starches which are high molecular polymers of glucose. One of the α-1,6-glucosidases is the enzyme form Pseudomonas amyloderamosa ATCC 21262. Suspensions of waxy corn starch of pH 4.0 to 5.0 were heated to effect gelatinization. After being quickly cooked to 45°C, Pseudomonas enzyme was added and the reaction was conducted for at least 15 hours (depending on the concentration of the initial enzyme). The processes only use starches, not whole cereal grains.

The Patent '380 asserts that alpha-1,6-glucosidase has so far been known as isoamylase when contained in yeast or as R-enzyme when contained in plants. Pullulanase from aerobacter aerogenes is also alpha-1,6-glucosidase. Other bacterial sources of enzymes which belong to alpha-1,6-glucosidase are disclosed. According to Patent '380.



Utilizing the properties of this enzyme, only the branched part of amylopectin in starch can be decomposed to obtain straight chain amylose alone having a chain length (i.e. degree of polymerization, D.P.) of near that of the branched part (D.P. 20). Thus, starches of complicated structures can be now converted into substances each having almost the same molecular weight and uniform structure.

U.S. Patent No. 3,897,305 discloses converting starch to dextrose by saccharifying a starch hydrolyzate with an enzyme system comprising glucoamylase and amylo-1,6-glucosidase at a pH which will inhibit the reversionary action of glucoamylase. The starch hydrolyzate can be obtained by thinning starch with an enzyme such as alpha-amylase and is saccharified with the above enzyme system at a pH of between 4.5 and 6.7. The enzyme amylo-1,6-glucosidase, quite often referred to as "pullulanase", is an enzyme capable of selectively hydrolyzing only alpha-1,6-glucosidic bonds of the amylopectin fraction of starch. Patent '305 asserts that other enzymes capable of hydrolyzing alpha-1,6-glucosidic bonds are referred to in the literature as "iso-amylase" and "R-enzyme."

U.S. Patent No. 3,922,196 discloses converting granular wheat starch to a soluble hydrolysate by agitating a mixture of granular starch, water, and an alpha-amylase and at least one saccharification enzyme at a temperature between the normal initial gelatinization temperature of the starch and the actual gelatinization temperature of the starch, and maintaining the starch in essentially granular form until a soluble hydrolyzate is produced. The specific saccharification

enzyme can be isoamylase. In a two-step process the granular starch is solubilized with alpha-amylase in a first step and the solubilized starch from the first step is treated with at least one saccharification enzyme in a second step. Col. 6, lines 45 to 47, col. 11, line 11, and col. 18, line 54, of Patent '196 refer to pullulanase as being an isoamylase enzyme.

U.S. Patent No. 4,254,150 teaches the production of cereal foods in flaked form. The starch in the particulated wheat grain is saccharified to dextrose by amyloglucosidase.

U.S. Patent No. 4,335,208 discloses saccharifying starch hydrolysate to high dextrose glucose syrup at pH 3 to 5 using an enzyme mixture of a glucoamylase and an acidophilic isoamylase.

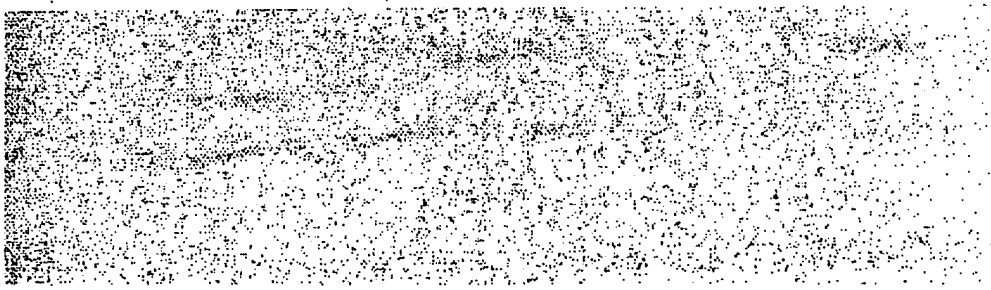
U.S. Patent No. 4,376,824 discloses producing a glucose/fructose syrup by enzymatically isomerizing an unrefined starch hydrolysate. The hydrolysate is prepared under controlled liquefaction and saccharification conditions to provide an isomerization substrate wherein the concentrations of calcium ions and non-enzymatically generated ketose sugars are maintained at low levels. Patent '824 also discloses treating an aqueous solution of starch with α-amylase and then further treating the partially hydrolyzed starch with glucoamylase.

U.S. Patent Nos. 4,431,674, 4,435,430, 4,656,040 and 4,710,386 disclose the production of enzyme-saccharified all natural ready-to-eat cereal from the endosperm fraction of whole wheat grain using α-amylase and glucoamylase.

U.S. Patent No. 4,454,161 discloses producing a food product containing an amylaceous substance by preparing an aqueous solution of an amylaceous substance, namely, amylose, amylopectin, starch, dextrin and mixtures thereof. The aqueous solution is subjected to the action of branching enzyme for a period sufficient to form substantial branches in the amylaceous substance. A food product containing the resultant branched amylaceous substance is prepared. In analysis step (C) in Example IV, the branched amylaceous is subjected to isoamylase enzymatic action. The action was suggested to be hydrolysis of the α-1,6-linkages by the isoamylase with linear dextrin formation.

U.S. Patent No. 4,560,651 discloses a pullulanase type debranching enzyme, obtained from strains of Bacillus acidopullulyticus, used in conjunction with saccharifying enzymes for the hydrolysis of starch into syrups. Patent '651, in its prior art section, states:

> "Obstacles akin to those described hereinbefore have been encountered in the conversion of starch to high maltose syrup by means of beta-amylases. Like the alpha-amylases, beta-amylases are only capable of partially degrading amylopectin, in that hydrolysis thereof stops as an 1,6-alpha-branch point is approached. By combining the action of beta-amylase with that of a debranching enzyme, such as pullulanase or isoamylase, a substantial increase in maltose content can be achieved as disclosed in



British Patent No. 1,144,950 and U.S. Patent No. 3,677,896."

The debranching of amylopectin by isoamylase is disclosed at col. 10, lines 48 to 66. The test was conducted on amylopectin using Pseudomonas isoamylase (Hayashibara Biochemical Laboratories, Inc.) for three days at 50°C (at pHs of 4.5 and 4.9 after incubation) and at 60°C (at pHs of 4.9 and 5.2 after incubation).

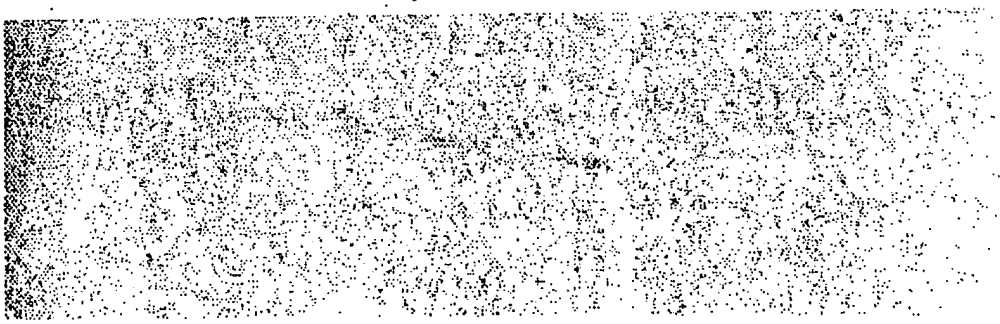
U.S. Patent No. 4,628,031 discloses hydrolyzing starch from a pullulanase and glucoamylase produced by Clostridium thermohydrosulfuricum. Col. 6, lines 50 to 53, reports that temperature optima for isoamylases are below 60°C.

U.S. Patent No. 4,657,865 discloses that isoamylase cleaves the α-1,6-glucosidic linkages of amylopectin or starch containing amylopectin.

British Patent No. 1,144,950 discloses subjecting partially hydrolyzed starch to a high maltose starch conversion product using, simultaneously or sequentially, a maltogenic enzyme preparation and a pullulanase enzyme preparation.

British Patent Application No. 81-07287 discloses the use of glucoamylase and the debranching enzyme Pseudomonas amyloderamosa isoamylase to produce syrups from starch. (The temperature is limited to about 55°C and below because of the heat lability of isoamylase -- see U.S. Patent No. 4,560,651, col. 2. The relative low temperature is said to substantially increase the risk of bacterial contamination.)

Broad Description of the Invention



An object of the invention is to provide a process for preparing a cooked cereal, particularly cooked wheat, in shredded form. Another object of the invention is to provide a process for the preparation of shredded breakfast cereals, particularly shredded wheat breakfast cereals.

The invention involves a process for the preparation of shredded, cooked, farinaceous cereal products, particularly shredded cooked wheat products. The invention process includes:

(a) cooking whole wheat berries with water to at least partially gelatinize the wheat starch, the bran layer of the whole wheat berries being intact and not having any penetrations therein before the cooking step begins;

(b) treating the cooked wheat berries with an R-enzyme in the presence of water;

(c) tempering the treated, cooked wheat berries for a sufficient period of time to retrograde a substantial portion of the starch in the berries;

(d) forming the tempered wheat berries into a shredded form; and

(e) baking or toasting the shredded wheat.

Any other suitable whole, farinaceous cereal grain can be used in place of the whole wheat grain (berries). Mixtures of whole, farinaceous cereal grains can be used.

In the process the grains are deformed from their discrete shapes into shreds. The starch provides formability of the grains into the ready-to-eat breakfast shredded (wheat) cereals. Starch is generally needed for its matrix forming

abilities so the grain can be deformed, blended, and conformed into ready-to-eat shredded (wheat) cereals.

The shredded wheat biscuits or shredded cereal biscuits are made from whole grain without, usually, the addition of any flavor and without the removal of the germ or bran. Flavorants, vitamin premixes, sugar and other additives can be added or placed on or in the biscuits, e.g., sugar based coatings.

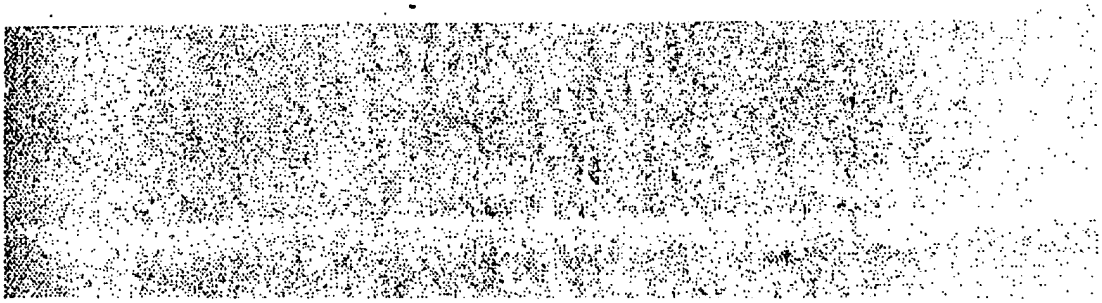
The invention also includes the production of shredded cereal biscuits which are filled with paste, nuts, etc.

The whole wheat berries are cooked in the presence of water to at least partially gelatinize the starch. The degree of gelatinization is typically complete.

The cooking can be as little as 15 minutes or as long as an hour or more, with a period of about 30 minutes being preferred. The cooking is preferably done in boiling water at atmospheric pressure. The cooking can be done at atmospheric pressure, lower pressure or higher pressure. The whole wheat berries or kernels are very soft.

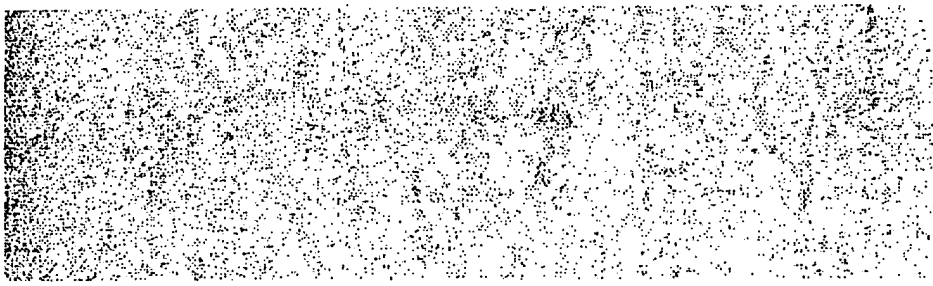
The moisture content after cooking may be as high as about 60 percent, although it is preferably about 50 percent, and normally should not be less than about 45 percent. Some preliminary drying in louver ovens can be done at this time, but the whole wheat should not be brought much below 45 to 50 percent of moisture.

The invention process is conducted on whole cereal (wheat) grains, which provides the quite unexpected feature that the whole cereal grains are rapidly penetrated by the R-



enzyme. The prior art has generally believed that the bran or outer coating of cereal grains must be removed or breached in order for enzymes to be able to penetrate into the interior of the cereal grains with any speed at all. The very fact of penetration, and even more that it is rapid, into the interior of the whole grains by the R-enzyme has meant the greatly reduced tempering time of the invention process. The penetration allows the conversion of the R-enzyme. The tempering time has been reduced by as much as 50 percent compared to typical shredded wheat production processes. This provides a substantial reduction in process time, manpower and capital investment (e.g., fewer tempering tanks are needed).

The R-enzyme enzymatic treatment is done only subsequent to cooking (at a lower temperature than cooking), although the R-enzyme treatment can be done simultaneously with the cooking step when one uses a heat-stable R-enzyme. With heat-stable R-enzyme, the enzyme treatment can be done after cooking at temperatures of 80° to 100°C. The higher treatment temperature speeds up the debranching. When the R-enzyme enzymatic treatment is done after cooking, the amount of water used during the R-enzyme enzymatic treatment is preferably limited so that at least substantially all of the water is absorbed by the cereal grain berries. The cooking of the cereal grain berries and the enzymatic treatment are performed so that the discreetness or integrity of the berries is substantially retained. This permits formation of the R-enzyme enzymatically treated particles into breakfast cereal shapes using conventional, mass production cereal forming equipment.



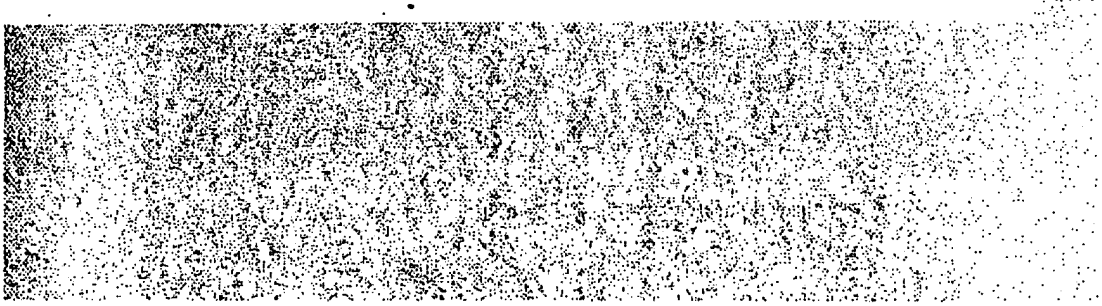
The tempering step of the R-enzyme treated cereal berries is usually about one half to three fourths of that of the conventional tempering step, which is conventionally up to about 48 hours, typically from about 20 to about 48 hours. With wheat berries, the conventional tempering time of wheat berries has been reduced to about one half to three fourths thereof, namely, 4 to 15 hours.

The tempering is preferably done in stainless steel bins or other stainless steel containers.

It is believed that the substantial reduction in tempering time achieved by the invention process is due to the debranching of at least a significant portion (say up to about 70 percent) of the amylopectin fraction of the wheat starch (or of the branched fraction of other cereal grain starch).

While not wishing to be bound to theory, it is theorized that the enzyme acts by debranching, i.e., breaking alpha 1,6 bonds in the amylopectin fraction of wheat starch, thus forming relatively short-chain linear amylose molecules (or similar short-chain molecules). The short-chain amylose is prone to retrogradation and insolubilization. One of the recognized effects of tempering cooked wheat berries prior to shredding is the development of retrograded starch which in turn promotes facile shredding and a strong web. The invention tempered composition has increased tensile strength and web forming ability.

In wheat not treated with R-enzyme, only the amylose fraction, which accounts for about 25 percent of the starch,



tends to retrograde. By treating the starch with R-enzyme the potentially retrogradable fraction is significantly increased.

The tempered product is then drained, and formed into shredded breakfast cereal. The enzymes are inactivated by heating of the shredded cereal; this can be achieved in the baking or toasting step. Enzyme inactivation can also be initiated prior to or simultaneously with the shredding step. Any suitable or conventional shredding equipment can be used. After being formed, the shredded wheat biscuits are toasted or baked using any suitable or conventional toasting or baking equipment.

The invention also involves the shredded, cooked, farinaceous cereal products, particularly the shredded, cooked wheat products, prepared by the process of the invention. The process includes:

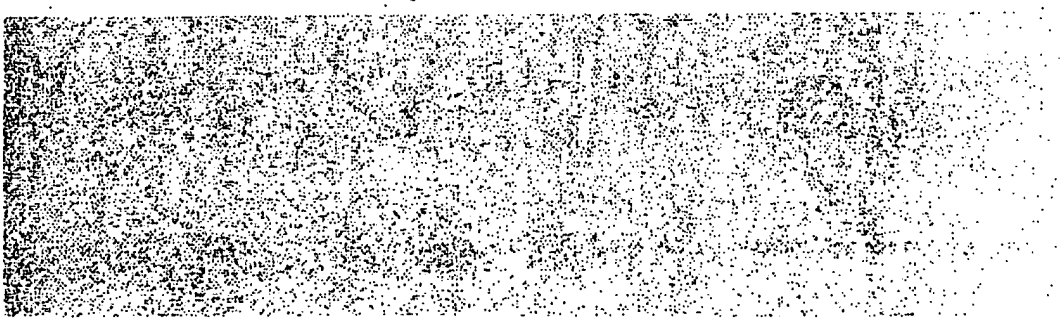
(a) cooking whole farinaceous cereal grain with water to at least partially gelatinize the cereal starch, the bran layer of the whole cereal grain being intact and not having any penetrations therein before the cooking step begins;

(b) treating the cooked cereal grain with an R-enzyme in the pressure of water;

(c) tempering the treated, cooked cereal grain for a sufficient period of time to retrograde a substantial portion of the starch in the grain;

(d) forming the tempered cereal grain into a shredded form; and

(e) baking or toasting the shredded cereal grain.



The breakfast cereals, particularly the breakfast wheat cereals, of the invention have excellent shape retention and integrity due to the increased amount of starch which was retrograded during the tempering step. The products obtained are at least equivalent to the commercial products.

Detailed Description of the Invention

As used herein, all percentages, ratios, parts and proportions are on weight basis unless otherwise stated herein or otherwise obvious here from to one skilled in the art. As used herein, all temperatures are in degrees Fahrenheit unless otherwise stated herein or otherwise obvious herefrom to one skilled in the art.

Naturally occurring starch components present in cereal grain berries are R-enzyme enzymatically altered to provide a shortened tempering time and increased starch retrogradation during production of the final product.

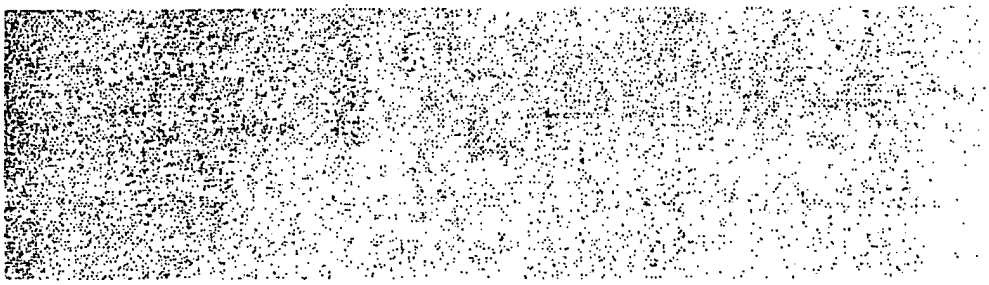
The invention relates preferably to wheat, but also includes other cereal (farinaceous) grains suitable for food within its scope. Other suitable cereal grains include oats, rice, corn, barley, buckwheat, sorghum, millet, rye, combinations thereof, and the like. Mixtures of farinaceous cereal grains can be used.

Corn starch has about 25 percent of amylose with the remainder being amylopectin. High amylose corn starch can run as high as 80 percent of amylose. Waxy corn starch has zero to about 3 percent of amylose; wheat starch has about 25 percent of amylose; and rice starch has about 17 percent of amylose. (See Lineback, David R., et al., ibid., pages 242

and 243.) Starch from milo or grain sorghum contains 20 to 30 percent of amylose and 70 to 80 percent of amylopectin. (See Pancoast, Harry M., et al., "Handbook of Sugars", Avi Publishing Company, Inc., Conn., (1980), page 152.)

Wherever possible, adjacent straight-chain amylose molecules and the outer branches of amylopectin associate through hydrogen bonding in a parallelwise fashion to give radially oriented, crystalline bundles known as micelles. These micelles hold the granule together to permit swelling in heated water without complete disruption and solubilization of the individual starch molecules. Lineback, David R., et al., ibid., pages 243 and 244. When the starch granule is heated in water, the weaker hydrogen bonds in the amorphous areas are ruptured and the granule swells with progressive hydration. The more tightly bound micelles remain intact, holding the granule together. Birefringence is lost. The temperature at which the birefringent cross disappears is the gelatinization temperature of that particular granule. As the granule continues to expand, more water is imbibed, clarity improved, more space is occupied, movement is restricted and the viscosity increases. Lineback, David R., et al., ibid., pages 244 and 245.

With the swelling of amylose-containing granules, some of the smaller amylose molecules are solubilized and leach out to reassociate into tight bundles which will precipitate if the starch concentration is low or will form a gel if the concentration is high. This is referred to as setback or retrogradation. The congealed paste will become cloudy and



opaque with time and will eventually release water and shrink into a rubbery consistency. Pastes from high amylose starch may set up very hard. Lineback, David R. et al., ibid., pages 245 and 246. Retrograded amylose is water insoluble. Both the gelation of amylose from concentrated solutions and precipitation from dilute solution can be termed retrogradation. The gels and precipitates formed result from the inherent tendency of amylose molecules to undergo conformational ordering and to subsequently align or aggregate. The rate of retrogradation increases with increasing amylose concentration and with decreasing temperature. Lineback, David R., et al., ibid., page 432.

The following description of the invention deals primarily with wheat but applies generally to any useful farinaceous cereal grains.

The invention uses whole wheat berries. The whole wheat berries should generally contain at least 10 percent by weight of wheat starch, suitable from about 25 to about 45 percent by weight, on a dry weight basis.

The invention does not include the use of whole wheat grain where the bran layer has been removed. Whole wheat grain which has been slightly crushed or "bumped" so as to break the bran coat but not destroy their unitary nature is not within the scope of being used in the invention. The invention also does not include comminuted wheat berries.

The whole wheat berries are cooked in the presence of water to at least partially gelatinize the starch. The degree of gelatinization is typically complete. By complete

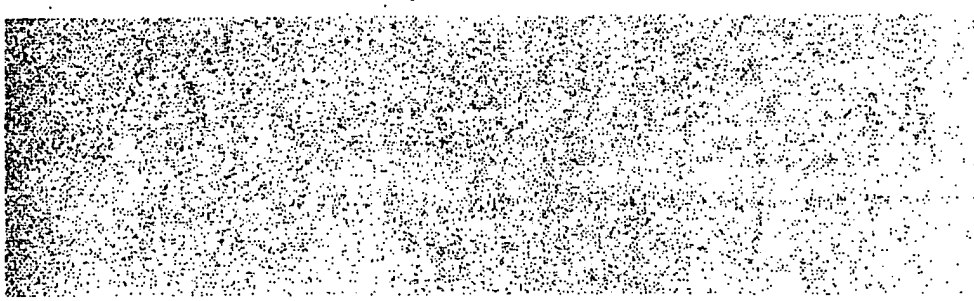
gelatinization it is meant that there is a complete absence of birefringence and complete absence of enthalpy of gelatination by differential scanning calorimetry.

Cooking temperatures generally range from about 176°F (80°C) to about 212°F (100°C). Cooking times generally range from about 15 to about 45 minutes. The pH during presoaking or cooking is suitably from about 2.0 to about 6. Generally the cooking times and temperatures should be sufficient to completely eliminate white centers or to leave only faint white centers in the whole wheat berries.

After being cooked, the wheat berries are treated with R-enzyme (in the presence of water) to significantly increase the retrogradable portion or fraction of the starch therein. Unless a heat stable R-enzyme is used, the invention is not successful if the R-enzyme is added before or during the cooking. The R-enzyme can be added to the tempering tank, after draining (from the cooking step) or before draining (from the cooking step). When a heat stable R-enzyme is used, the heat stable R-enzyme can be added before or during the cooking. If heat stable R-enzyme is used after cooking, the temperature that can be used is above 80°C.

One of the surprising aspects of the invention is the phenomenon of the R-enzyme actually penetrating the intact, cooked wheat berry thus allowing effective debranching.

The whole wheat berries and water are admixed with the R-enzyme. (The amount of R-enzyme used can be reduced by surface coating the cooked wheat berries with the enzymatic solution.)



The R-enzyme treatment is suitably conducted at a temperature of from about 68°F (20°C) to about 176°F (80°C) and a pH of from about 3 to about 9, preferably from about 100°F (40°C) to about 167°F (75°C) and a pH of from about 3.5 to about 8. The R-enzyme treatment can be conducted at a temperature up to and including boiling if a heat stable R-enzyme is used. Generally the use of the native pH of the starch can be used as the pH level for the R-enzyme treatment and tempering steps.

The pH during the R-enzyme enzymatic treatment can be controlled with an edible buffer, but buffers are not necessary since the wheat will maintain a pH of about 5.6. An acetate buffer comprising a mixture of acetic acid and acetate is preferred. The pH can also be adjusted continuously by the use of a pH adjuster, such as, sodium hydroxide, potassium hydroxide or calcium carbonate. Other buffers or pH adjusters which can be used include propionates, lactates, fumarates, malates, citrates and phosphates, such as potassium phosphate.

The total time of the R-enzyme treatment is suitably up to about 2 hours, preferably from about 30 minutes to 1 hour.

R-enzyme is an α-1,6-glucosidase obtained from plants. Any isoamylase which hydrolyzes (i.e., breaks) the α-D-(1,6) linkages of amylopectin can be used.

R-enzymes are plant derived debranching enzymes of the pullulanase type. R-enzymes debranch amylopectin and its beta-limit dextrins, but cannot attack glycogen beta-limit dextrins. As they are direct branching enzymes, R-enzymes hydrolyze the α-(1-6)glucosidic bonds of glycogen and

amylopectin by splitting off side chains of varying lengths. R-enzymes can hydrolyze poly α-(1-6)maltotriose (pullulan).

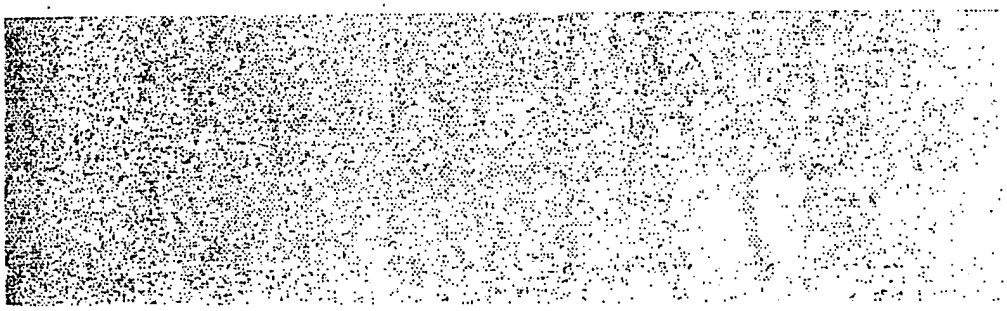
R-enzymes can be obtained from bread beans, potatoes, cereals, such as, oats, barley and sweet corn, for example.

The R-enzyme used must be reasonably stable and exhibit good activity at the pH and temperature ranges used in the invention process. If an R-enzyme is thermally stable, it can be added to the whole cereal grain before cooking.

R-enzyme from potatoes and broad beans has an optimum pH of 6.5 to 7.0 and an optimum temperature of about 34°C. (See Hobson, P.N., et al., ibid., page 1452.) It exhibits over 90 percent activity between pH 2.5 and 4.5 and between 45° to 50°C. R-enzymes are generally unstable outside of the pH range of from 4.5 to 8.5 and at a temperature over 50°C.

This invention does not include the use of glucoamylases, microbial pullulanases or indirect debranching enzymes. Microbial pullulanase will provide some debranching but it is not very effective on intact starch. Microbial pullulanase tends to provide fragments which are too short to allow significant retrogradation, whereas R-enzymes provides fewer amounts of such fragments which allow retrogradation as R-enzymes hydrolyze less amylopectin than microbial pullulanases.

The R-enzymes can be assayed by measuring the increase in the iodine color at 610 nm using amylopectin as a substrate, Yokobayashi, K., et al., Agr. Biol. Chem., 16, 1493 (1969); Yokobayashi, K., et al., Bio. Chem. Bio. Physics Acta, 212, 458-469, (1970). The iodine value (blue value) scheme is used



to determine the degree of hydrolysis of the interchain branch points. 2016950

An iodine value determination method which can be used herein is:

Twenty grams of shredded wheat and 200 ml of deionized water are blended in an Osterizer at "liquefy" speed for 3 minutes and at "stir" speed for 4 minutes. Approximately 10 ml of this solution is centrifuged for 5 minutes at about 1200 rpm. Six milliliters of the supernatant is added to a 100-ml volumetric flask containing 2 ml of a I_2/KI solution (I g of I_2 and 4g of KI into 100 ml of deionized water; dilute 1:10 before using) and 20 ml of 0.1 M sodium phosphate buffer at pH 7. The solution is brought to volume with deionized water and the absorbance is read at 600 nm after five minutes.

One unit of R-enzyme is defined as that amount of enzyme which will produce 1 mg of maltose equivalent per ml of digest from a 0.5 percent pullulan solution in 60 minutes at 45°C and pH 5.0. Based upon the R-enzyme nase assay procedure, the units of R-enzyme per ml of production culture media can be determined by the following equation:

$$\text{units/ml} = \frac{\text{mg of maltose}}{\text{1 ml of digest}} \times \frac{\text{60 min.}}{\text{digestion time of test sample (in min.)}} \times \frac{\text{1 ml}}{\text{.5 ml (diluted test sample)}}$$

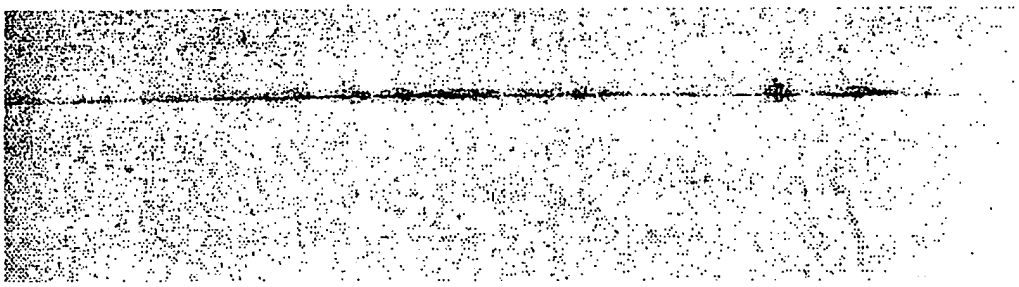
Preferably, 20 to 50 R-enzyme units per ml. of water and wheat or cereal berries is used.

Basically, the R-enzyme enzymatically converts at least a significant or substantial portion (up to about 70 percent) of the amylopectin to relatively short-chain linear amylose

molecules. (These short-chain amylose molecules are shorter than those produced by isoamylase.) This means that there is a significant or substantial increase in the amount of amylase present which can be retrograded during the tempering step. The amount of the amylopectin which is converted to amylose can range up to about 70 percent by weight on a dry amylopectin dry basis. (However, the conversion to low molecular weight amylose should not be so high as to destroy formability or machinability or to reduce final wheat cereal product strength.) The larger degree of retrogradation means increased matrix formation or machinability capability of the tempered wheat berries.

The R-enzyme treatment, by debranching the amylopectin, substantially reduces the time needed to achieve tempering. The treated starch in the whole cereal grains is more soluble than that secured in the conventional processes, which reduces the tempering time. The R-enzyme treatment modification converts amylopectin into a low molecular weight compound which will have a rapid rate of retrogradation, a much reduced viscosity, and allow for an increased rate of moisture migration during tempering. The use of R-enzyme though is not as good as isoamylase since the former produces shorter fragments, which means less retrogradation, and generally provides less reduction in tempering time.

The R-enzyme enzymatic conversion is conducted so as to retain the discreetness or integrity of the whole wheat berries.



The amount of water used during cooking and during enzymatic treatment with the R-enzyme is preferably limited so that at least substantially all of the water is absorbed by the whole wheat berries. Suitably, the amount of water used during cooking and R-enzyme enzymatic treatment ranges from about 20 to about 55 percent by weight, based upon the total weight of water and whole wheat berries. Water can be added after cooking for admixture of R-enzyme with the cooked whole wheat barriers so as to achieve homogeneity during enzymatic treatment. After enzymatic treatment, any additional water remaining is drained.

After being treated with R-enzyme, the R-enzyme treated wheat berries are tempered for a sufficient period of time to retrograde a substantial portion of the starch in such berries. Suitably the tempering is conducted for 15 hours or less, typically for 4 to 12 hours, preferably 6 to 16 hours. There must be sufficient time for sufficient retrogradation to occur. Tempering of the whole wheat berries occurs after cooking and during the R-enzyme treatment and the separate tempering step. During the tempering of the drained, R-enzyme-treated whole wheat berries, water is distributed substantially uniformly throughout the whole wheat berries prior to forming. The pH of the tempering fluid (in the berries) is between about 4 and about 10, and preferably about 7.2.

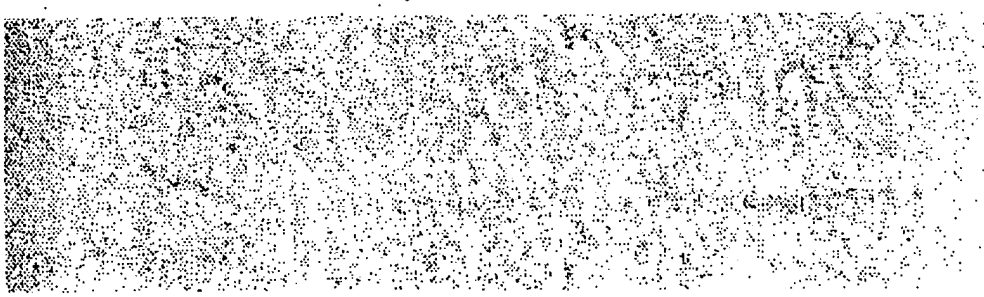
After being tempered, the tempered, whole wheat berries are formed into shredded breakfast cereal shapes by using any

suitable production or conventional (mass) production cereal processing equipment.

In the production of a ready-to-eat shredded wheat biscuit, suitable moisture contents of the R-enzyme enzymatically treated whole wheat berries for shredding range from about 28 to about 49 percent by weight, more typically from about 39 to about 43 percent by weight, based upon the weight of the whole wheat berries. The cooked, tempered, R-enzyme enzymatically treated whole wheat berries are transferred, suitably by means of belt conveyors, to a hopper which feeds a screw conveyor. The latter transfers the whole wheat berries to a series of shredding rolls or mills via flow tubes or hoppers.

Shredding systems which can be used in the production of shredded wheat are disclosed in U.S. Patent Nos. 502,378, 2,008,024, 2,013,003, 2,693,419, and 4,004,035 and Canadian Patent No. 674,046.

The formation of square, rectangular or triangular shredded wheat biscuits is described as follows. The shredding mills comprise a pair of rolls that rotate in opposite directions. One of the rolls has circumferential grooves and crosshatching grooves which are transverse to the circumferential grooves for the production of an integral net-like sheet. The spacing between the rolls is preferably controlled so as to avoid the production of webbing. Upon passing between the rolls, the whole wheat berries are deformed into the circumferential grooves and the crosshatching grooves. Each pair of rolls produces a wheat



dough layer having a plurality of generally parallel longitudinal strands and a plurality of crosshatchings generally perpendicular to the strands. The longitudinal strands are produced by the circumferential grooves and run in parallel with the direction of movement of an underlying conveyor. The crosshatchings of the wheat dough layer are produced by the crosshatching grooves and run generally perpendicular to the direction of movement of the conveyor.

The shredding mills are arranged in a linear series along the common underlying conveyor. Each of the shredded wheat dough layers or sheets are deposited on the conveyor in superposition, with their longitudinal strands running in the same direction.

The shredded wheat dough layers are continuously laminated. The laminate is cut transversely and longitudinally to the direction of flow of the product into multiple lines of biscuit preforms using known cutting devices. The cutting can be completely through the laminate to form the individual biscuit shapes prior to baking or toasting. However, cutting partially through the filled laminate to form biscuit shapes, followed by baking and separating the baked partially cut laminate into individual biscuits in known manner is preferred. This procedure provides easier control of the orientation of a cut product as it passes through the oven.

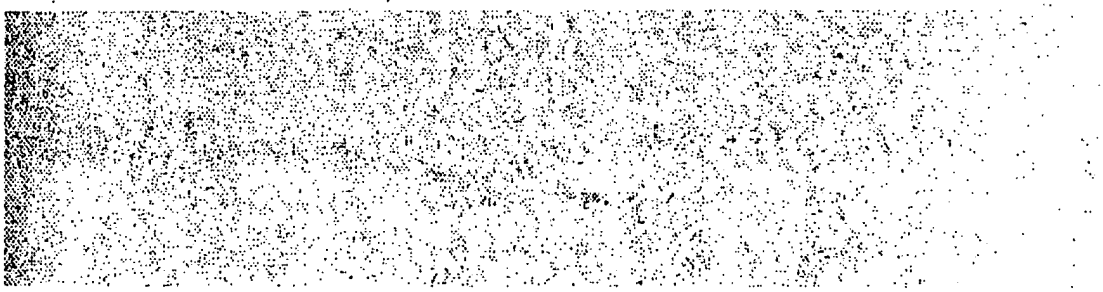
The shredding rolls are usually from 6 to 8 inches in diameter and as wide as the finished biscuit is to be and, thus, are much smaller than flaking rolls. On one of the pair

of rolls is a series of about 20 shallow corrugations running around the periphery. In cross section, these corrugations may be rectangular, triangular, or a combination of these shapes. The other roll of the pair is smooth. Soft cooked wheat is drawn between these rollers as they rotate, and issues as continuous strands of dough.

Biscuits are built up by layering strands on a moving belt which passes under sets of rolls working in tandem. Ten to 18 rolls may be used for circular biscuits, while 22 rolls is a common number for rectangular biscuits. In the latter case, layered strands are separated into biscuits by passing them below blunt knives which fuse a thin line of the dough into a solid mass at regular intervals.

The tempering step allows for sufficient starch retrogradation and equilibration of moisture so that the grain on shredding forms continuous, straight, non-sticky, semi-elastic strands. Retrogradation is the crystallization that occurs in gelatinized starch upon cooling. Insufficient tempering results in curled, sticky, and broken webs upon shredding.

After being formed, the shredded wheat berries are baked or toasted. The R-enzyme can be completely inactivated to provide a shelf stable product suitably by heating during the conventional baking, toasting and drying steps. For example, in the production of a shredded biscuit product, the cut laminate can be dried, baked and toasted in conventional equipment. Suitable ovens for drying, baking and toasting the laminate include Proctor and Schwartz, Werner-Lehara and



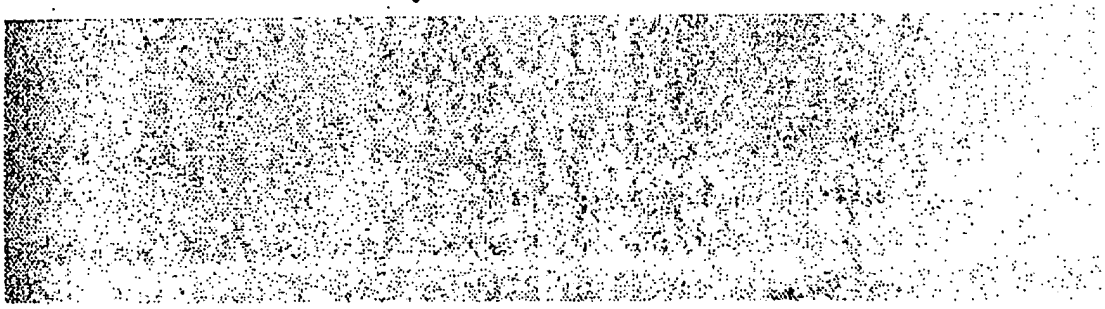
Spooner ovens containing forced air and gas fired burners and conveyor. Temperature profiles used in the oven for the drying, baking and toasting of the biscuit preforms are generally within the range of about 200°F to about 600°F. Temperatures within this range are generally suitable for total enzyme inactivation. The total time for drying, baking and toasting should be such so as to avoid excessive browning. Suitable times for drying, baking and toasting will depend upon matters such as product thickness, product size and oven type. Suitable times generally range from about 4 to about 10 minutes.

In some operations, the forming and baking/toasting steps occur simultaneously, or nearly simultaneously, in the same equipment.

The formation of bite-sized shredded breakfast cereals is described as follows: A triple shredding mill is used for producing bit-sized breakfast cereals. Dough made from wheat, corn or rice, for example, is fed to long, water-cooled shredding rolls. These rolls deposit a shredded dough sheet onto a constant speed conveyor to form a wide, three-layer ribbon. The rolls on the first and third shredding mills extrude dough sheets with a laced pattern, due to the presence of smooth and grooved rolls. The middle set of rolls revolves at higher speed than the other two sets. As a result, the dough sheet in the middle folds as it falls onto the relatively slow moving conveyor belt covered by the first sheet. Sugar can be sprinkled over the middle dough sheet, and the top sheet is added. The combined structure passes

between scoring rolls, and the baked cereal is finally broken along scored lines to form individual bit-sized pieces.

The formation of circular shredded wheat biscuits is described as follows: One end of the sheet formed from layered strands of whole wheat dough is caught up by a smooth roll which rotates just above the belt. This roll turns the layer of strands back upon itself, and the forward motion of the belt, combined with the reverse and upward motion of the cylinder surface, causes the layer to roll up into a circular biscuit. As the biscuit reaches the proper size, a knife chops down on the belt, severing the strands so that the former biscuit is released. Automatic controls vary the speed of the belt as the diameter of the biscuit increases. The completed disk falls into a cup from which it is transferred to a belt leading to the ovens. Since the biscuits are formed from dough of relative high moisture content, they are quite tender, and must be handled very carefully to prevent distortion. In practice, this means that the transfer steps must proceed relatively slowly. The wet biscuits are placed on a metal belt moving through a high temperature gas-fired oven. After 10 to 15 minutes, the outside of the product is dry and toasted while the interior is still wet. Then the biscuits are transferred to another hot air oven (or to a different section of the same oven) where they are dried, for example, at 250°F for 30 to 60 minutes for a time depending upon the size and the air flow. Finished moisture content is usually about 11 percent. The combination of heat treatments



causes the biscuit to assume the familiar oval cross section as a result of differential shrinkage of the layers.

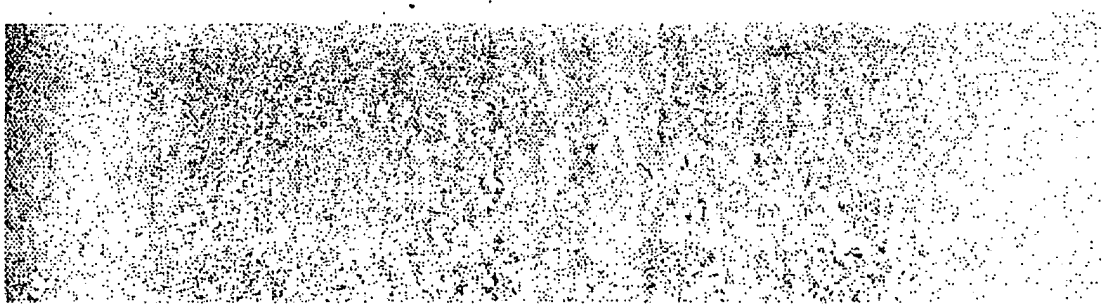
The invention also includes the production of shredded cereal biscuits which are filled with paste, fruit, nuts, raisins, partially-dehydrated honey, partially-dehydrated fructose syrup and/or the like. The production of shredded cereal products having a fruit paste filling is taught in U.S. Patent Nos. 2,693,419, 4,004,035 and 4,696,825. The pertinent portions of U.S. Patent Nos. 2,693,419, 4,004,035 and 4,696,825 are incorporated herein by reference.

According to U.S. Patent No. 2,693,419 the shred form is superior to other cereal forms, such as flakes, puffs, and the like in that it does not become soft and soggy when containing relatively high percentages of moisture. Dried fruit is enclosed within cereal shreds to provide a product wherein the cereal and dried fruit are essentially integral. After the fruit has been enclosed within the cereal shreds, it is taught, the cereal may be processed at elevated temperatures without any substantial adverse affect on the texture and flavor of the fruit. The shredded product is prepared by depositing layers of moist, cooked shreds on top of each other in the process of U.S. Patent No. 2,693,419. Usually after about half of the shred layers have been laid down, the fruit is deposited on the shreds and the remainder of the shred layers are laid down on top of the fruit. The shreds, it is taught, may be produced by means of a shredding machine comprised of a series of shredding heads, each of which consist of a pair of rolls revolving toward each other. The

cereal elements are forced between the rolls and into the grooves contained therein to drop in a continuous flow of shreds onto a conveyor belt situated beneath the shredding machine.

U.S. Patent No. 4,004,035 teaches the production of a shredded biscuit having a lapped zig-zag configuration in which the shreds are disposed on an angle relative to the sides and ends of the biscuits and the shreds of individual layers are disposed on opposite or crossing angles. The biscuit, it is taught, is more rugged than a conventional biscuit which is produced using shredding mills which are arranged in a linear series across a common conveyor, with the shreds running longitudinally or in parallel with the direction of movement of the conveyor. In the process of U.S. Patent No. 4,004,035, the addition of a second lapping device allows the introduction of a flavoring filling between the laps, resulting in a filled shredded biscuit having a lapped zig-zag configuration. Each lapping device is fed by one or more conventional shredding mills comprising a pair of closely spaced rolls wherein preferably one of the rolls has a smooth circumference and the other has a grooved circumference.

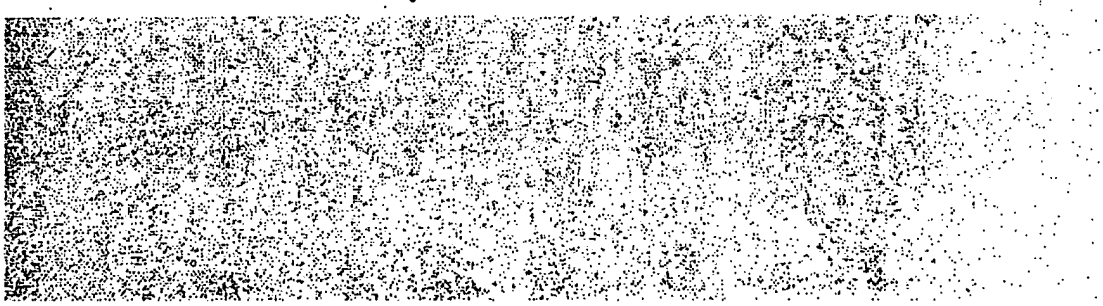
The U.S. Patent No. 4,696,825 discloses a process for the continuous production of microbially shelf-stable paste-filled shredded cereal biscuits having an extended shelf-stable plurality of textures. A first plurality of net-like sheets of cereal dough are continuously laminated, followed by continuous depositing of at least one extrudate rope filling upon the first plurality of net-like sheets. A second



plurality of net-like sheets is continuously laminated upon at least one extrudate rope to obtain a filled laminate. Each of the net-like sheets has a plurality of generally parallel longitudinal strands and a plurality of crosshatchings which are generally perpendicular to the longitudinal strands. The filled laminate is cut to enrobe the filling and the product is baked. The number of crosshatchings of the net-like sheets adjacent to the filling is greater than the number of crosshatchings of the net-like sheets which are further removed from the filling.

The fillings used in the filled shredded can be a fruit paste filling, a meat filling, a cheese filling, or the like which is not adversely affected by the baking of the biscuit portion. Meat fillings and cheese fillings are intended for products to be eaten as a snack whereas fruit paste fillings are intended for ready-to-eat breakfast cereals or as snacks. Exemplary of fruit paste fillings which can be used are raisin paste fillings, strawberry, apple, apricot, banana, fig, peach, pear, prune, and mixtures thereof. They may include seasonings such as cinnamon or the like. The fillings may contain artificial and/or natural flavorings, and nuts.

The filling should be formulated to provide a microbially shelf stable product having a water activity of less than about 0.7. Fillings having a higher water activity can be used with a suitable preservative, such as sodium benzoate. Pastes having a water activity of less than about 0.6 prior to baking are preferred so as to assure the attainment of a

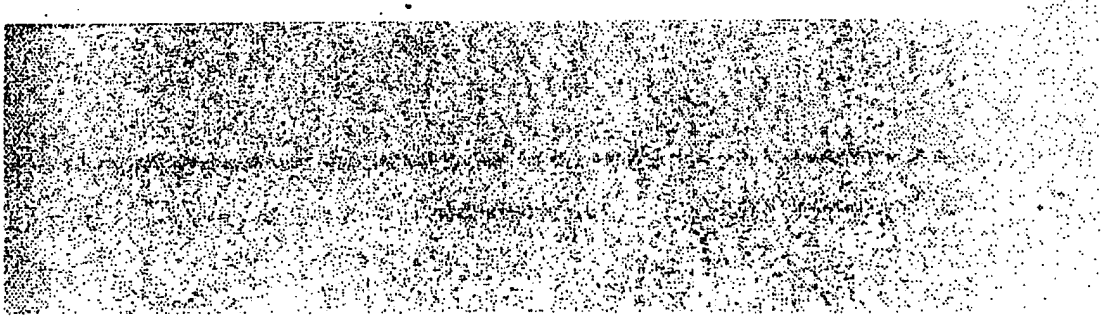


microbially safe baked product and to inhibit moisture migration to the baked dough layers.

The filling should provide an impression of moistness and be soft and chewy in the baked product under proper packaging and storage conditions. Fruit paste fillings comprising dehydrated fruit and glycerin or other edible humectant polyols and/or sugars may be used. Glycerin levels ranging from about 5 to about 25 percent, preferably from about 8 to about 12 percent by weight, based upon the total weight of the filling have been found to provide a desirable moist, soft or chewy texture in the baked product without adversely affecting taste. Suitable fruit paste fillings typically have a water content of at least about 12 percent by weight of the extrudate rope filling.

The formed shredded wheat biscuits are dried, baked and toasted in conventional equipment. Suitable ovens for drying, baking and toasting the cut filled laminate include Proctor & Schwartz, Werner-Lehara, Wolverine and spooner ovens containing forced air and gas fired burners and a conveyor.

Temperature profiles used in the oven for drying, baking and toasting of the biscuit preforms are generally within the range of about 200°F to about 600°F. The total time for drying, baking and toasting should be such so as to avoid browning. It depends upon the number of shred layers, the size of the shredded product, the filling, and the type of oven. The total time for drying, baking and toasting typically ranges from about 5 minutes to about 10 minutes.

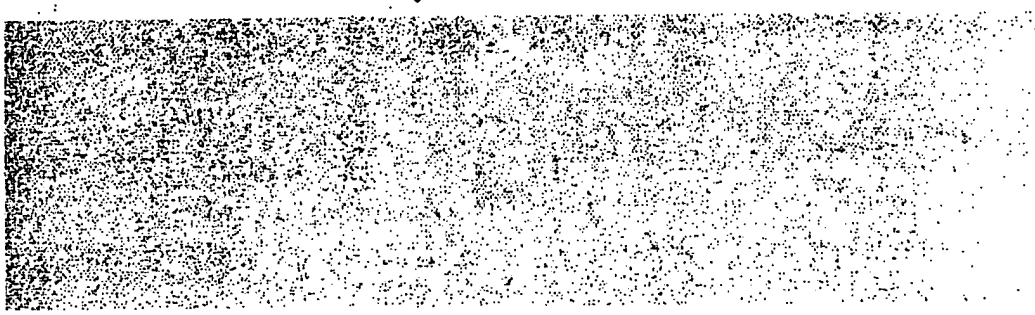


The final product suitable has an average moisture content of about 6 to about 12 percent, more preferably from about 7 to about 8 percent by weight, based upon the weight of the final product, as determined by a Karl-Fischer moisture analysis. The water activity of the final product should be less than about 0.7, preferably less than about 0.6 when properly packaged. With proper packaging, the filling and the shredded cereal portions of the product reach equilibrium with respect to water activities within about two weeks.

The color of the final baked product should be a substantially uniform off-white to light golden tan color. The baked product can be topped with salt or other flavoring or spray oil by top and/or bottom spraying in conventional manner.

The cereal portion of the filled biscuit may contain one or more additives at the usual levels of concentration. Exemplary thereof is a sugar such as sucrose, salt, malt, flavoring, food colorant, emulsifier, vitamins and/or minerals.

During the invention process, the retention of the integrity or discreetness of the whole wheat berries and retention of starch or high molecular weight dextrins is needed for formability or machinability into shredded wheat breakfast cereal shapes on conventional processing equipment. In the production of shredded wheat, the R-enzyme enzymatic treatment of whole wheat berries should not destroy the integrity or discreetness of the whole wheat berries. If discreetness is destroyed, the grains tend to clog shredding



roll feed hoppers and tend to stick to the shredding rolls. The retention of starch or matrix-forming high molecular weight dextrins should be sufficient so as to provide machinability and formability as well as to provide resistance to breakage in the final wheat product.

The flavor of the shredded wheat differs markedly from that of whole wheat flakes because the latter includes added condiments and are subjected to much more heat in both the cooking and the toasting step. The more rigorous heat treatment applied to flakes results in considerably more caramelization in the finished product.

Rancid odors tend to accumulate if the shredded wheat is stored in sealed containers. For this reason, the shredded wheat product is sometimes packaged in boxes without outer or inner linings. When so packaged, the product is just as stable to storage deterioration as any other prepared cereal except that moisture absorption may occur in atmospheres of high relative humidity with a consequent loss of crispiness. Preferably, in spite of these factors, an inner lining is used.

Commonly-owned co-pending patent application Serial No. 101,561, filed on September 28, 1987, applicant: John A. Maselli, entitled "A Method For Making Cereal Products Naturally Sweetened With Fructose" (as amended), deals with the production of breakfast cereals by the treatment of cereal grains or cereal grain fractions with enzymes. The pertinent portions of said application Serial No. 101,561 are incorporated herein by reference.

WHAT IS CLAIMED IS:

1. Process of preparing a shredded wheat product:

(a) cooking whole wheat berries with water to at least partially gelatinize the wheat starch, the bran layer of the whole wheat berries being intact and not having any penetrations therein before the cooking begins;

(b) treating the cooked whole wheat berries with an R-enzyme in the presence of water;

(c) tempering the treated, cooked, whole wheat berries for a sufficient period of time to retrograde a substantial portion of the starch in said berries;

(d) forming the tempered, whole wheat berries into a shredded form; and

(e) baking or toasting the shredded wheat product.

2. The process as claimed in Claim 1 wherein the cooking is done at a temperature of from about 176°F (80°C) to about 212°F (100°C) and a pH of from about 2 to about 8.

3. The process as claimed in Claim 1 wherein the amount of water present during the R-enzyme enzymatic treatment of the wheat grains is limited so that at least substantially all of the water is absorbed by the wheat grains.

4. The process as claimed in Claim 3 wherein the amount of water present during the R-enzyme enzymatic treatment ranges from about 20 to about 55 percent by weight, based upon the total weight of the water and the weight of the wheat grains.

5. The process as claimed in Claim 1 wherein the enzymatic treatment with the R-enzyme takes place at a temperature of from about 68°F (20°C) to about 176°F (80°C) and at a pH of from about 4 to about 9.

6. The process as claimed in Claim 1 wherein the R-enzyme is used in an amount of 20 to 50 R-enzyme units per ml. of admixture of water and whole wheat berries.

7. The process as claimed in Claim 1 wherein the time duration of the tempering treatment is 15 hours or less.

8. The process as claimed in Claim 1 wherein the time duration of the tempering treatment is from 4 hours to 12 hours.

9. The process as claimed in Claim 1 wherein the R-enzyme enzymatically treated wheat grains are shredded into integral net-like sheets, the sheets are laminated, the laminate is cut, and the cut laminate is baked to inactivate the enzymes.

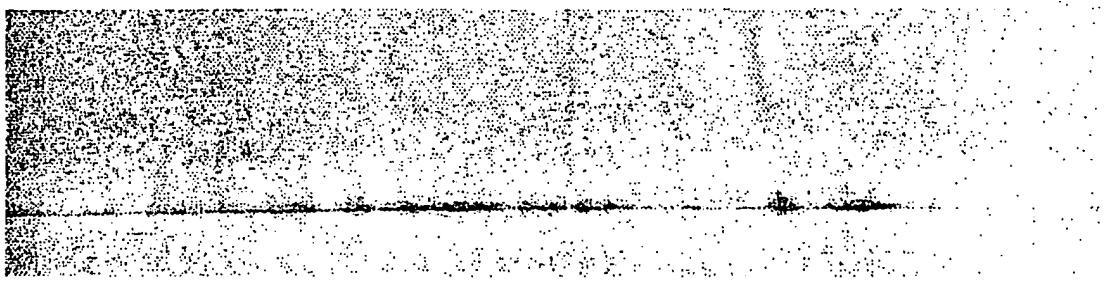
10. The process as claimed in Claim 1 wherein the R-enzyme is inactivated by baking the shreds.

11. The process as claimed in Claim 1 wherein the R-enzyme is inactivated by toasting the shreds.

12. The process as claimed in Claim 1 wherein the shreds are filled with a food paste.

13. The shredded, cooked wheat biscuits prepared by the process of Claim 1.

14. Process of preparing a shredded, farinaceous cereal product:



(a) cooking whole farinaceous cereal grains with water to at least partially gelatinize the cereal starch, the bran layer of the whole cereal grains being intact and not having any penetrations therein before the cooking begins;

(b) treating the cooked whole cereal grains with an R-enzyme in the presence of water;

(c) tempering the treated, cooked, whole cereal grains for a sufficient period of time to retrograde a substantial portion of the starch in said grains;

(d) forming the tempered, whole cereal berries into a shredded form; and

(e) baking or toasting the formed cereal grains.

15. The process as claimed in Claim 15 wherein the farinaceous cereal grains are select from the group consisting of oats, rice, corn, barley, buckwheat, sorghum, millet and rye.

16. The process as claimed in Claim 15 wherein the cooking is done at a temperature of from about 176°F (80°C) to about 212°F (100°C) and a pH of from about 2 to about 8.

17. The process as claimed in Claim 15 wherein the amount of water present during the R-enzyme enzymatic treatment of the cereal grains is limited so that at least substantially all of the water is absorbed by the cereal grains.

18. The process as claimed in Claim 18 wherein the amount of water present during the R-enzyme enzymatic

treatment ranges from about 20 to about 55 percent by weight, based upon the total weight of the water and the weight of the cereal grains.

19. The process as claimed in Claim 15 wherein the enzymatic treatment with the R-enzyme takes place at a temperature of from about 68°F (20°C) to about 176°F (80°C) and at a pH of from about 4 to about 9.

20. The process as claimed in Claim 15 wherein the R-enzyme is used in an amount of 20 to 50 R-enzyme units per ml. of admixture of water and whole cereal grains.

21. The process as claimed in Claim 15 wherein the time duration of the tempering treatment is 15 hours or less.

22. The process as claimed in Claim 15 wherein the time duration of the tempering treatment is from 4 hours to 12 hours.

23. The process as claimed in Claim 15 wherein the R-enzyme enzymatically treated cereal grains are shredded into integral net-like sheets, the sheets are laminated, the laminate is cut, and the cut laminate is baked to inactivate the enzymes.

24. The process as claimed in Claim 15 wherein the R-enzyme is inactivated by baking the shreds.

25. The process as claimed in Claim 15 wherein the R-enzyme is inactivated by toasting the shreds.

26. The process as claimed in Claim 15 wherein the shreds are filled with a food paste.

27. The formed cooked cereal biscuits prepared by the process of Claim 15.

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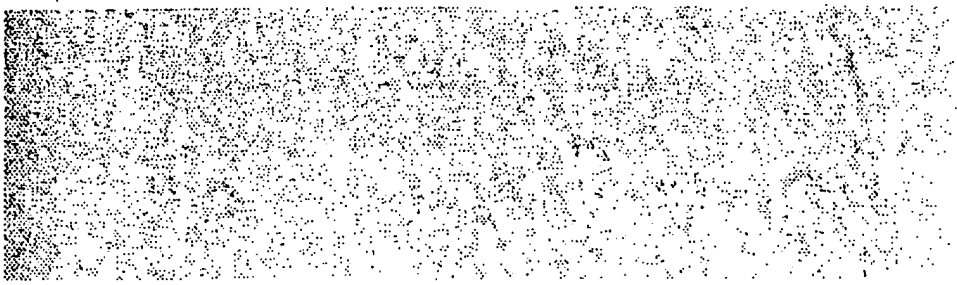

ABSTRACT OF THE DISCLOSURE

A process of preparing a shredded wheat product. The process includes cooking whole wheat berries with water to at least partially gelatinize the wheat starch. The bran layer of the whole wheat berries is intact and does not have any penetrations therein before the cooking begins. The cooked wheat berries are treated with an R-enzyme. The treated, cooked wheat berries are tempered for a sufficient period of time to retrograde a substantial portion of the starch in the berries. The process allows the use of a tempering time which is much less than the tempering period in the conventional or commercial process of preparing shredded wheat. The tempered wheat berries are formed into a shredded form and then baked or toasted.